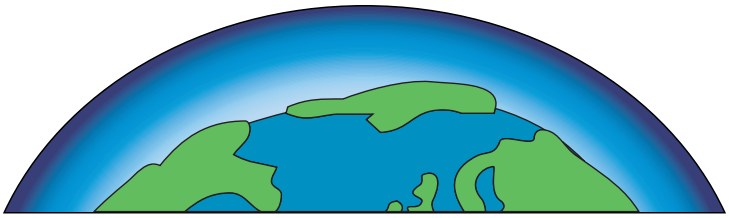


Lesson 2: Building Blocks of Matter

Students are introduced to atoms, molecules and elements. They explore the differences in the bonds of atoms of different elements and how atoms stick together and bond to form molecules.

Main Lesson Concept: The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules.

Scientific Question: What are the building blocks of matter? What are their properties? How do they behave?

Objectives	Standards
• Students will explain that the atoms of any element are alike and have the same properties and characteristics but are distinct from atoms of other elements. • Students will show how atoms can be grouped into molecules.	**Meets:** 2061: 4D (6-8) #1 **Partially meets:** NSES: B (5-8) #1.3 NSES: B (9-12) #1.1 NSES: B (9-12) #2.2

Assessment	Abstract of Lesson
Responses to Astro Journal final questions.	Students build constructions out of different types of building materials as a metaphor for atoms and molecules. They interpret different symbolic representations for molecules and kinesthetically model the bonding of different atoms into molecules.

Prerequisite Concepts	Major Concepts
• Humans need oxygen, carbon dioxide, nitrogen, ozone, and water vapor in certain quantities. (Atmosphere Lesson 1) • Matter is made up of atoms that are too small to see with a microscope (see suggested activity below, if your students have had no previous experience with the size of atoms.) • Matter is made up of molecules that are bonded together. (Astronomy Lessons 3-5) • Solids, liquids and gases have different properties because of the difference in the strength of the bonds between molecules. (Astronomy Lessons 3-5) • Materials may be composed of parts that are too small to be seen without magnification. (2061: 4D (3-5) #3) • Air is a substance that surrounds us and takes up space. (2061: 4B (3-5) #4)	• Atoms are the building blocks of all matter. • Atoms of any element have the same properties and characteristics. • Atoms are distinct from atoms of other elements. • Atoms bond with other atoms to form molecules.

Suggested Prerequisite Activity on the Size of Atoms/Thinking in Scale:

Engage students in the Size of Atoms/Thinking In Scale discussion and activity.

- Question: How large is an atom?
- *Answer: The average atom has a diameter .00000002 cm or 2 hundred millionths of a centimeter. Write the correct answer on the board.*

- Say: Let's see if we can visualize this.
- Give each student a 2 cm^2 piece of paper. Write, "2 cm" on the board.

  Note to Teacher: The 2 cm^2 piece of paper may be too small for many students to work with. You may use a larger square to represent the 2 cm^2 piece of paper so that the students can have the kinesthetic experience of cutting the paper into tenths and observing and extrapolating the regression down to the size of atoms. Inform students of the initial difference in scale. Unlike other situations, it will not affect final results.

- Have the students cut the squares into 10 roughly even pieces. Write "0.2" cm on the board to represent this new size.

- Have students take 1 of the 10 pieces (discard the rest) and try to cut it into 10 even pieces. Write "0.02" cm on the board to represent this new size.

- Question: "How many more times would we have to do this in order to have a piece the size of an atom?
- *Answer: Six more times. Show the movement of the decimal point to get to the size of one atom.*

- Give students hand lenses, magnifying glasses, or microscopes to view the paper underneath.

- Question: Do you think we could actually trim this down to the size of an average atom? Why or why not?
- *Answer: No, you could not, because the cutting tools are larger than the average atom.*

- Question: Let's think of this another way. If the diameter of an average atom is 2 hundred millionths, how many atoms would it take to go across our original 2 square cm piece of paper?
- *Answer: It would take one hundred million. Solve the problem on the board, if the students seem unsure of how you calculated it.*

- Question: How could we figure out the number of atoms that are across the surface of that piece of paper?
- *Answer: Multiply one hundred million by one hundred million. The result is 10 quadrillion.*

- Say: The current world population is around 6.2 to 6.4 billion people. That means there are over 1.5 million times more atoms on the surface of your two-square-inch piece of paper than there are people on Earth.

- Have students describe the size of atoms and use specific examples in their descriptions.

Suggested Timeline (45-minute periods):
Day 1: Engage and Explore Sections
Day 2: Explain and Extend Day 1 Sections
Day 3: Extend Day 2 and Evaluate Sections

Materials and Equipment:
- 3 materials each with different properties for each group (blocks, fabric, and string or rubber bands are suggested)
- A class set of Astro Journals Lesson 2
- A class set of Atoms, Elements, and Molecules Reading
- A class set of Chemical Diagrams Sheet
- Signs or name tags for each student to indicate the element they represent

Preparation:
- Gather materials.
- Duplicate Astro Journal; Atoms, Elements, and Molecules Reading; and Chemical Diagrams Sheet.
- Prepare classroom. Make sure there's room for the Kinesthetic Atoms Activity in the Extend section.
- Prepare chart paper with the major concept of the lesson to post at the end of the lesson.

Differentiation:

Accommodations
For students who may have special needs:
- Provide extra support for the reading assignment (e.g. partner, read aloud, etc.)
- Have them work with a partner on the Astro Journal writing or report orally to the teacher.

Advanced Extensions
For students who have mastered this concept:
- Research and report how molecular bonds work.
- Research and report on the structure of atoms.

Engage (approximately 10 minutes)

1. **Review important atmospheric gases from Atmosphere Lesson 1.**
   - Question: What gases do we need in order to survive on Earth?
   - *Answer: We need oxygen, carbon dioxide, nitrogen, ozone, and water vapor.*

   - Question: How might these gases differ from each other?
   - *Answer: (Allow students to discuss their ideas about this.)*

- Question: What have we figured out about these gases?
- *Answer: In order to be habitable to humans, we need:*
  - 0.0001 to 20% water vapor
  - 0.001 to 0.03% carbon dioxide
  - more than 80 Dobson Units of Ozone in the stratosphere
  - 15 to 30% oxygen
  - More than 5% nitrogen

2. Review states of matter concepts from Astronomy Lessons 3-5.

- Question: In Astronomy, what did you learn are the properties of each state of matter?
- *Answer:*
  - *Solids have a fixed volume and a fixed shape.*
  - *Liquids have a fixed volume and no fixed shape.*
  - *Gases have no fixed volume and no fixed shape.*

- Question: What causes each of these states to be different?
- *Answer: The amount of energy affects the movement of the molecules and their ability to break their bonds. In solids, molecules have less energy and their movement is not enough to break the bonds. Liquids have more energy, increasing the movement and beginning to break some of the bonds, and in gases, the energy has increased enough that molecules can completely break their bonds.*

- Question: So, what do you already know about what makes up matter?
- *Answer: We know that matter is made up of molecules that are bonded together.*

- Say: So we know that a substance can change depending on the strength of the bonds.

- Question: Are water and ice the same substance? How do you know?
- *Answer: (Allow students to discuss and share ideas.) Water and ice are made of the same molecules, but the strength of the bonds in each is different.*

- Say: So we already know how a substance can change state but still be the same substance. Today we are going to look at what makes two substances different.

3. Draw on students' prior knowledge of how substances are different.

- Question: Are salt and sugar different substances?
- *Answer: Yes.*

- Question: Salt and sugar look the same, so how do you know they are different?
- *Answer: They taste different.*

- Question: What do you think makes salt and sugar different, even though they look the same?
- *Answer: (Allow students to think about this and share their ideas before stating the following.) Scientists have studied this question for a very long time and have concluded that different substances are made of different atoms or molecules.*

4. Introduce the purpose of the lesson.

- Say: Just like salt and sugar are different, so are the gases in our atmosphere. We may not be able to see the difference between oxygen and nitrogen, but we can tell when there is not enough oxygen to survive. By understanding the atoms and molecules that make up each gas and what makes each unique, we can understand why each is important to human survival.

5. Introduce the Scientific Questions.

- Question: What are the building blocks of matter?
- *Answer: Atoms make up all matter.*

- Question: Can we see atoms?
- *Answer: No. Atoms are so small, they cannot even be seen with a microscope.*

- Say: The Scientific Questions we will be exploring are:
  - What are atoms and molecules?
  - What are the properties of atoms and molecules?
  - How do they behave?

- Say: In this lesson we're going to be thinking about matter in terms of building blocks.

Explore (approximately 35 minutes)

1. Guide students in the Building Activity.

- Pass out materials for the students to build with. Blocks (most any type), fabric, and string (or rubber bands) will do. Just make sure that the three materials have different properties. Go over activity directions with students and give them five to ten minutes to build something with them.

- Students record their constructions in their Astro Journals and share them with the class.
- Discuss similarities and differences in the designs and purposes of the constructions.
- Students generate lists of properties of the pieces:
  - Blocks: hard, solid
  - Fabric: soft, flexible
  - String: very flexible

- Generate lists of properties of the constructions:
  - Some possibilities: stable, strong, (size and shape)

- Students compare and contrast the properties of the parts with the properties of the constructions and record their findings in their Astro Journals.

- Have students reflect on the similarities and differences between the building materials and atoms, as well as between the constructions and molecules.

Explain (approximately 25 minutes)

1. **Discuss the similarities and differences between atoms and the building materials, as well as between molecules and constructions . (You may want to record responses in a T-chart or table.**
   - Say: Your building materials and construction are a model for atoms and molecules. For any model, there are good comparisons, but it's also important to recognize the differences.

   - Question: How are atoms like your building materials?
   - *Answer: Different kinds of atoms have different properties, just like different building materials have different properties.*

   - Question: How are atoms different from your building materials?
   - *Answer (answers may include the following):*
     - *Atoms are much smaller.*
     - *Atoms are held together by bonds. Building materials require glue, tape or some other way of attaching them.*
     - *In reality, the materials themselves are made of molecules and can be broken down into atoms, whereas an atom is the smallest building block of a pure substance.*

   - Question: How are molecules like your constructions?
   - *Answer (answers may include the following):*
     - *Molecules are made out of smaller pieces called atoms. Our constructions are made out of smaller building materials.*
     - *Molecules can be made of different kinds of atoms, and our constructions are made of different types of building materials.*
     - *Atoms can make many different molecules like carbon dioxide or water, and building materials can be used to make many different constructions.*
     - *If we add more atoms to a molecule, it becomes a new and different substance. If we build additional parts to our construction, it is not the same construction as before*
     - *The properties of a molecule are determined by the atoms that compose the molecule. The properties of our construction are determined by the types of building materials used.*

2. **Have students read the Atoms, Elements, and Molecules Reading.**

3. **Discuss atoms, elements, and molecules.**
   - Question: If building materials are like atoms, and a construction is like a molecule, what can we compare elements to?
   - *Answer: Elements are the types of building materials. A block is an element. String is a different element.*

   - Question: Most everything on Earth is made of twenty major elements. How is this possible?
   - *Answer: Each substance on Earth is made of different numbers and combinations of the elements. There are many possible combinations of elements.*

   - Question: What are some examples of elements?
   - *Answer: Some examples are oxygen, hydrogen, nitrogen and carbon. (If students give examples of substances that are composed of multiple elements such as water or carbon dioxide, point out that these are molecules composed of multiple atoms of different elements. This will lead nicely into the next activity.)*

Extend/Apply Day 1 - (approximately 20 minutes)

1. Guide students in the Building Blocks of Gases Activity.

- Say: Now that we understand the difference between atoms and molecules, let's see how atoms combine to build some of the gases we know are important for human life.
- Write the following chemical formulas on the board: oxygen (O_2) carbon dioxide (CO_2) water vapor (H_2O) nitrogen (N_2) and ozone (O_3).
- Say: Here are the formulas of our molecules. Chemists use letters and numbers to tell us about the molecule. Each letter or combination of letters refers to a specific element. Some elements have two letters, such as magnesium, which is "Mg." In that case, the first letter is capitalized--the second is not. The number refers to the number of atoms of that element in the molecule.
- Say: For example, the formula for water is H_2O. That means there are two atoms of the element hydrogen and one atom of the element oxygen.
- Have students read and interpret the other formulae.
- Add the diagrams of the formula to the board from the Chemical Diagrams Sheet.
- Question: This is another way of representing a molecule. This shows us a bit more information. What do you think these lines mean?
- Students write their predictions in their Astro Journals.
- Add the diagrams for methane (CH_4), ammonia (NH_3), and formaldehyde (CH_2O). Have the students try to find patterns in the letters and lines.

  Note to Teacher: The pattern is the number of bonds (represented by the lines) associated with each element: hydrogen tends to form one bond; oxygen tends to form two bonds; nitrogen tends to form three bonds and carbon tends to form four bonds. There are many exceptions to these rules. In fact, chemistry is partially about understanding and manipulating the rules and exceptions.

- The students record the patterns in their Astro Journals.
- Discuss student predictions.
- Tell them the lines in the formula indicate the connection or "bond" between the atoms in the molecule. The bond is what "holds" the molecule together. The positions of the letters show the general "shape" of the molecule. This is a very general "shape."

Extend/Apply Day 2 - (approximately 15 minutes)

1. Lead students in the Kinesthetic Atoms – The Parts of Molecules Activity.
   - Tell students that they will be modeling the molecules of the gases they are studying.

MISCONCEPTION: If the students have done the kinesthetic modeling from other lessons in the Astronomy module, each student was an individual molecule and the group was a collection of those molecules. In the Atmosphere module, each student (or pair of students) is an atom of a specific element, and a group will make up a single molecule. It is important to make sure the students are clear what part they are playing in the each model they make.

- Guide students to model the elements. You may want to have students wear a sign or name tag with the element they represent.
  - Modeling hydrogen requires one student who holds one hand out to "bond" with another atom while keeping the other hand at his or her side.
  - Modeling oxygen requires one student who holds both hands out to "bond" with one or two other atoms.
  - Modeling nitrogen requires two students next to each other. One holds out two hands to "bond" while the other holds out one.
  - Modeling carbon requires two students back-to-back both holding out two hands to "bond."

2. **Have students model gas molecules.**
   - Have the students model hydrogen gas, H_2 (each holding on to the other's hand).
   - Have the students model oxygen gas, O_2 (both holding onto the other with both hands).
   - Have the students model nitrogen gas, N_2 (the two pair of students facing each other – matching hands held).
   - Have the students model carbon dioxide, CO_2 (each oxygen person is holding two hands of the carbon pair).
   - Have the students model water, H_2O (each of the hydrogen person holds one of the oxygen person's hands).
   - Have the students model ozone, O_3. (Two students hold onto the other with both hands to form O_2. One other student places one hand on the shoulder of one of the students in the oxygen gas molecule.)
   - Optional: Students model methane (CH_4), ammonia (NH_3), and formaldehyde (CH_2O).

     Note to Teacher: Ammonia and formaldehyde are liquid under Earth-normal conditions.

   - Tell the students that these are examples of how molecules tend to interact with each other. Given the same conditions, any atom of a certain element will behave like any other atom of that element but unlike any other element. In other words, any hydrogen atom will behave like any other hydrogen atom, but not like an oxygen atom as long as the two atoms are under the same conditions. There are many factors such as the amount of heat (or other kinds of energy), charges, or the presence of other elements that can change how atoms interact to form molecules. Many of these factors are understood and predictable. Other factors are being studied by scientists.

   - Tell the students that ozone, O_3, is an example of a molecule that forms under certain conditions. They will learn more about it in Lesson 6.

   - Tell the students that in future lessons, they will be learning more about the properties of the gases they're studying and the elements that are the building blocks of those molecules.

Evaluate (approximately 30 minutes)

1. **Have students complete the Final Questions in their Astro Journals.**

2. **Discuss students' responses to ensure they have mastered the major concepts.**
   - Question: What is matter made of? What is the relationship between atoms, elements, and molecules? How do they behave?
   - *Answer: Matter is made up of atoms. Just as there are different types of building materials, there are different kinds of atoms called elements. Atoms stick together or "bond" to form molecules.*

   - Question: How does hydrogen tend to bond with other atoms?
   - *Answer: Hydrogen tends to form a single bond.*

   - Question: How does oxygen tend to bond with other atoms?
   - *Answer: Oxygen tends to form two bonds.*

   - Question: How does nitrogen tend to bond with other atoms?
   - *Answer: Nitrogen tends to form three bonds.*

   - Question: How does carbon tend to bond with other atoms?
   - *Answer: Carbon tends to form four bonds.*

   - Question: What does this tell you about atoms of different elements?
   - *Answer: Atoms of different elements behave differently and have different properties.*

   - Question: Explain how the atoms in carbon dioxide are bonded together.
   - *Answer: Carbon has four bonds, and oxygen has two bonds. So carbon uses two bonds to bond with one oxygen atom and two more bonds to bond with another oxygen atom.*

   - Question: What does this tell us about one factor that causes gases to have unique properties?
   - *Answer: The way an element bonds gives it unique properties from other elements.*

3. **Collect students' Astro Journals and evaluate them to ensure that they have each mastered the major concepts:**
   - All matter is made up of atoms.
   - The atoms of any element are alike but are different from atoms of other elements.
   - Atoms may stick together in well-defined molecules.

4. **Bridge to next lesson.**
   - Today we learned about atoms, elements and molecules and their unique properties due to their different bonds. In the next lesson we'll begin to learn about how the unique properties of gases make them important to human survival.

   Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Astro Journal Atmosphere Lesson 2:
Building Blocks of Matter

Name:

Class/Period:

Date:

Building Activity

Directions: You have three different types of material. Use all three types to build a model of something. Whatever you build must:

- include some of all three materials
- have a purpose (for example – to carry something, hold something, protect something, etc.)

When you have built your model:

1. Make a sketch of your model and label the major parts in the left box below.
2. In the right box below, write a short description of:
   - the purpose of the model
   - how each material is being used

1.

2.

Purpose: _____

_____

_____

_____

Material 1: _____

_____

_____

_____

Material 2: _____

_____

_____

_____

Material 3: _____

_____

_____

_____

Astro Journal Atmosphere Lesson 2:
Building Blocks of Matter

Class/Period:

Date:

Properties of Materials and a Model

Directions: Fill in the left side of the table below with the properties of the materials used to build the model. In the right side, list the properties of one of the models made by you or your classmates.

1. Properties of Materials

Material 1: _____

Material 2: _____

Material 3: _____

2. Properties of a Model

3. Question:

How are the properties of the model similar to the properties of its parts? How are they different?

Astro Journal Lesson 2: Building Blocks of Matter | Name:

Class/Period: | Date:

A Model for Atoms and Molecules

1. How are your building materials like atoms?

Building Materials	Atoms

2. How are your building materials different from atoms?

Building Materials	Atoms

3. How is your construction like a molecule?

Construction	Molecule

4. How is your construction different from a molecule?

Construction	Molecule

Building Gases

1. In the space below, describe any patterns you see in the elements and line combinations.

Final Questions

Respond to the following questions in short paragraphs (two to five good sentences each).

1. Explain what matter is made of. Be sure to explain the relationship between atoms, elements, and molecules.

Final Questions (continued)

2. Describe how each of the following elements tends to bond with other atoms.
   - Hydrogen

   - Oxygen

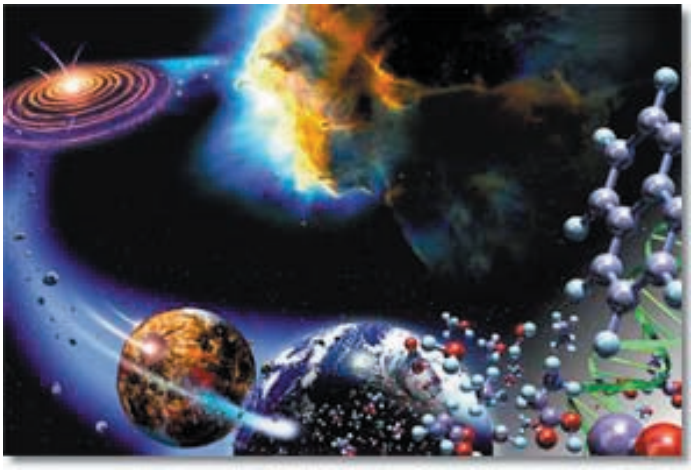
   - Nitrogen

   - Carbon

3. Draw the chemical formula for carbon dioxide and explain how the atoms are bonded together.

4. What does this tell us about one factor that causes gases to have unique properties?

Atoms, Elements and Molecules Reading



You have had a chance to explore **atoms** (the building blocks that make up all **matter**) and **molecules** (composed of several atoms). Your building materials were like atoms, and your constructions were like molecules. Each building material had different **properties** from other building materials.

Similarly, building materials used to create buildings, containers, jewelry or other tools have different properties. For example, **metals** are often used as a building material and may include aluminum, copper, silver and gold. Each of these metals varies in color, strength and other properties. These metals are sometimes combined with each other to form a substance with a new property. For example, pure gold is a very soft metal that is often combined with silver, copper and zinc to form a stronger metal that will not change its form as easily. The atoms that compose a substance determine its properties.

When a substance is pure and is composed of one kind of atom, it is called an **element**. There are more than one hundred different elements, but most of the substances in the universe are made with twenty or so of the most common ones.

Each element has its own unique properties, and every atom of that element will have those same properties. These properties include: size, mass, **melting point**, **boiling point**, and color.

The way in which an atom of an element **bonds** with other atoms is also a property. Each element bonds with other atoms in a characteristic way. When atoms are bonded together, they form molecules. Molecules can be as simple as two oxygen atoms bonded together, or they can be highly complex chains involving hundreds of atoms of many different elements.

For example, the element carbon has four available spots to bond with other atoms, while the element oxygen has two. One carbon atom and two oxygen atoms can combine to form a molecule of carbon dioxide. Each of the oxygen atoms bonds with two of the carbon atom's open spots. In truth, there are factors that can drastically change how atoms bond together, but the changes follow rules that are predictable.

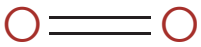
Atoms and elements are the building blocks of molecules, and molecules are the building blocks of matter. Different combinations of atoms (building blocks) can create very different substances. Carbon dioxide (CO_2) and methane (CH_4) both have carbon in them, but the gases have different properties from one another, and the properties of those gases are different from the properties of pure carbon, oxygen, or hydrogen.

The properties of carbon dioxide, water vapor, nitrogen gas, oxygen gas, and ozone make them essential to support life on Earth. In many cases, the amount of the gas in the atmosphere is also important. As you continue in the Atmospheric Science Training Module, you will understand why these gases are needed in certain amounts.

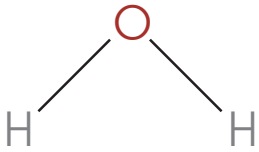
Chemical Diagrams Sheet

Carbon Dioxide (CO_2)

Hydrogen Gas (H_2)



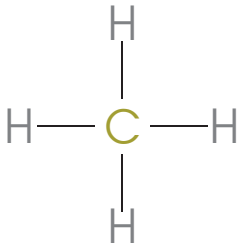
Oxygen Gas (O_2)



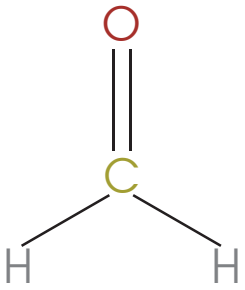
Water (H_2O)

Ozone Gas (O_3)

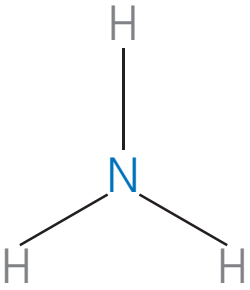
Nitrogen Gas (N_2)



Methane (CH_4)



Formaldehyde (CH_2O)



Ammonia (NH_3)